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THE EFFECTS OF LEARNER CONTROL AND AMOUNT OF CONCEPTUAL INFORMATION ON DIAGNOSTIC SKILL LEARNING

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

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ABSTRACT

The Effects of Learner-Control
and Amount of Conceptual Information
on Diagnostic Skill Learning

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This study examined how knowledge retention and the acquisition of diagnostic skills are influenced by the amount of conceptual information presented and the degree of interactivity present during training. Eighty undergraduate and graduate Rice University students were randomly assigned to one of four training programs that varied in the amount of conceptual information presented and the level of interactivity allowed during training. Performance was assessed immediately after training and again at one week after training. Subjects receiving interactive training performed significantly better immediately after training and again after one week. Subjects receiving more conceptual information did not perform significantly better than subjects receiving less conceptual information. These findings suggest that training programs should be made interactive when possible. They further suggest that providing additional conceptual information does not necessarily improve performance.
ACKNOWLEDGMENTS

To my advisor, David Lane:
"Thank you for believing in me, for your patience, help, and counsel."

To my husband José L., my son José O., and my daughter Ydamith:
"For your patience, patience, and patience."

To both, my advisor and my family, from my heart:
"THANK YOU!
You made this accomplishment possible!"
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INTRODUCTION

The goal of any training program is to provide the trainee with a repertoire of skills that will facilitate an efficient and safe system operation (Wickens, 1992). Training is an integral part of our lives, and the skills we need to function adequately are purportedly given to us as we are trained at home, at school, and in the work place.

What makes a training program efficient? The ideal training program provides the best learning in the shortest amount of time, with the longest retention and at the lowest cost possible. To meet these demands successfully, the design of training programs must take into account the needs of the people being trained. These needs can only be addressed after these questions are answered: (1) What characteristics of the information to be presented yield the best learning? (2) What is the best method of teaching the skill? and (3) What skills does the trainee need to learn? (Wickens, 1992).

To study the effects that characteristics of the information and the method of training have on the acquisition and retention of knowledge and diagnostic skills, a training program was designed and tested. The main issue was whether interactive training would be better than non-interactive training. A secondary issue was whether the amount of conceptual information presented would make a difference.
Characteristics of the Information: The Effect of Using Conceptual Versus Procedural Information During Training on Criterion Performance

Conceptual or declarative information is static information that describes the properties of an object whereas procedural information is information that explains how to use that object (Winograd, 1975). In general, conceptual information is defined as a theory about the system whereas procedural information is defined as either a stated set of rules or as some type of heuristic.

There is some disagreement regarding the usefulness of conceptual and procedural information in training. Two paradigms have been used to study this question: (1) expert troubleshooters are compared to novice troubleshooters in terms of their knowledge and how they approach and solve the task; and (2) two or more groups are given different training conditions and they are tested in a troubleshooting or process control task.

Expert versus novice troubleshooters

Morris and Rouse (1985), in their review of empirical research on troubleshooting, stated that novice troubleshooters, in contrast to expert ones, know less about how the equipment functions, have more incorrect hypotheses, are less likely to recognize critical information and make fewer checks. Gitomer (1988) concluded that experts have better organized knowledge of the task, are more likely to have a dynamic model of the task, and are more likely to use efficient strategies to access relevant information.
The effect of conceptual and procedural information in training

There is evidence that transfer is improved when conceptual information about the relationships among system variables is presented during training. For example, Patrick and Haines (1988) compared the effect of two training materials, a technical story and a set of diagnostic heuristics, on the acquisition and transfer of fault-diagnosis skills in a simulated chemical plant. The ability to diagnose faults was assessed for familiar faults (faults for which they had been trained) and novel faults in two plants: the plant for which they were trained and a different plant. In both the technical story group and the diagnostic heuristic group, positive transfer occurred on familiar faults at the same and at a different chemical plant. The performance of the technical story group was superior on novel faults similar to the faults they were trained on but not on novel faults of a different type from the ones they were trained on. These results were replicated by Patrick, Haines, Munley, and Wallace (1989) in a study that compared training with a qualitative model of the relationships among system variables and training with a set of heuristics. They found that the performance of subjects trained in the qualitative model was superior to those trained with the heuristics in the diagnosis of novel faults of the same category, but that no transfer occurred for the diagnosis of faults in a different chemical plant.

Morris and Rouse (1985) concluded that conceptual instruction is not effective in training troubleshooting. In one study supporting this conclusion (Shepherd, Marshall, Turner, & Duncan, 1977) subjects were trained using three different introductions to an industrial plant: a description of the plant and its functions (declarative information), a set of rules (procedural
information), or no information. Performance on fault-diagnosis of familiar and unfamiliar faults was assessed. Groups trained with a set of rules were more accurate than the other two groups at diagnosing unfamiliar faults. Marshall, Duncan, and Baker (1981) followed up on these findings and found that fault-diagnosis training could be enhanced by providing the information needed to apply a rule only when requested by the trainee as opposed to having all information available at all times.

On the other hand, Swezey (1991) found that subjects trained through procedural information were more accurate in their troubleshooting performance, although they took more time and checked more components (correctly and incorrectly), than subjects who received conceptual information or an integrated approach. On transfer to a different task, subjects trained with the integrated approach performed better than the others. Swezey concluded that an integrated approach should be used when generic troubleshooting skills are the purpose of training, and that some level of generic structure/function information facilitates cross-domain transfer.

Conclusion

Research is inconsistent regarding the optimal mix of procedural and conceptual information to be used in training. This inconsistency might be due, at least in part, to how concepts and procedures are defined within experiments, and how these operational definitions compare to the definitions used by other researchers.

Although research is inconsistent, it appears that some degree of conceptual information is needed if transfer is desired. A well-designed integrated approach that provides the advantages of both conceptual and
procedural information might be the best approach. Still the question remains as to how much information, conceptual or procedural, should be provided and whether there is a tradeoff between these types of information.
The Effect of Using Learner-Control Interactivity During Training on Criterion Performance

Interactive training has been loosely defined as training where the user has some amount of control over the course and content of instruction (Lambert & Sallis, 1987; McNeil & Nelson, 1991). Some researchers have criticized the lack of definitional specificity as well as theoretical and methodological deficiencies of published research. In a review of learner-control research, Reeves (1993) concluded that learner-control is not a well-defined concept in that what the user is controlling is a critical aspect of the definition that is not always taken into account. He also stated that not only does the research tend to be atheoretical, but it has methodological problems such as infrequent and brief treatments, and lack of relevant measures. Cronin and Cronin (1992) pointed out that most research on interactive video instruction lacks a unifying theory, and that no comprehensive theory has emerged from that research. However they stated that this research has led to specific applications that appear to positively affect learning, such as guided pathways for inexperienced users and instructional cues.

Tiemann and Markle (1990) distinguished between two types of interactivity: (1) learner-control interactivity meaning that the program allows the user to choose what, when, and for how long to see the material and (2) system-control interactivity meaning that the program can adapt itself to the users’ current level of achievement.

The idea that interactivity occurs in a continuum from total learner-control to total program-control was presented by Milheim and Martin
(1991). They argued that learner-control interactivity research focuses on users' choices of the content being studied (what), the sequence in which the material is presented (when), and the pacing of presentation (for how long), whereas total program-control interactivity leaves the user no choice over what, when, or for how long to study the material.

Research in this area has produced conflicting conclusions regarding the usefulness of learner-control interactivity. A possible explanation of the inconsistency is that learner-control is affected by learner characteristics such as aptitude and previous knowledge of the content (Milheim & Martin, 1991).

Learner-control has been used as a variable in many different areas of training. Despite the mixed results and different operational definitions plaguing this area of research, the one factor that research in this area has in common is allowing the subjects in the learner-control interactivity group the freedom to chose for how long they interact with the material presented; comparison groups do not have that freedom. It is often the case that a difference in training times between the groups becomes part of the design because no effort is made to control it. Time spent on training then becomes a confounding factor because if one group spends more time in training then this time difference, and not interactivity, becomes a plausible explanation for any measured differences.

One way to approach the complexity caused by the mixed results in this area is to compare studies by calculating the standardized difference between the group receiving learner-control and its comparison group
(Cohen, 1977). These differences and descriptions of the comparison groups are presented in Appendix A.

It is necessary to distinguish the studies with similar training times between the comparison from those where training time was not reported or one group received more training. They are grouped here into three categories: studies in which training time was not reported, studies in which training time differed by more than 25%, and studies in which training time was similar.

**Studies in which training time was not reported**

A study by Levenson, Morrow, and Signer (1985) supports the efficacy of learner-control interactivity. They presented their subjects with information about the nature of smokeless tobacco, the effect of nicotine on the body, and the social consequences of its usage. Only the subjects in the interactive group were asked questions at key points in the lesson and, if they answered them incorrectly, could choose to repeat the question series, review and respond again, or receive feedback. Subjects in the other groups (video watched individually, video watched in groups, and a no-training control) were not given such an opportunity. The interactive video group recalled the information significantly better than did the other three groups. The majority of the students (69%) that participated in the interactive training were also willing to assume an active role and suggest to others that they stop using the tobacco. Students who went through the other forms of training were more willing to leave the group when the smoker was present or stay and not say anything. The researchers concluded that this type of interactive training could be an alternative to more traditional forms of
training for health-related instruction. The standardized difference between the interactive and non-interactive video was $d = 1.38$ when the non-interactive video was presented to groups of subjects and $d = .93$ when the non-interactive video was presented to subjects individually. Although this appears to support the use of interactive video, it can also be argued that the interactive group merely had more training; they had the opportunity to repeat and review the information whereas the other groups did not, and that it was this difference that lead to the better performance of the interactive group.

Murphy and Davidson (1991) trained senior nursing students in the concepts of hypovolemic shock, cardiogenic shock, and vascular tone shock. Students were assigned to one of three experimental groups: learner-control (full control), adaptive control (no control), learner advisement strategy (full control after feedback). During training, the concepts were presented and followed by a series of scenarios portraying the particular concept. Control was exercised over the number of scenarios that could be seen after each concept was presented. The post-test, short-term, and long-term performance of the groups was not significantly affected by the training manipulation. The standardized difference for learner-control versus adaptive control on long term performance was $d = .10$, whereas for learner-control with advisement versus adaptive control on long term performance was $d = -.02$. Since these differences were small, in opposite directions, and nonsignificant, they provide no evidence of an effect of interactivity.

Another study in which the choice to review or not was present was Ho, Savenye, and Haas (1986). In this study, subjects received training on
computer interface installation via computer-based interactive video with
different modes of review: (1) Learner-controlled review (LCR) in which
subjects chose whether to review, (2) Computer-controlled review (CCR) in
which subjects were forced to review, or (3) No review (NR). Both the LCR
group and CCR group performed significantly higher than the NR group.
The researchers concluded that it was the opportunity to review, forced or
not, that facilitated learning. The standardized difference supports this
conclusion; the comparison between the learner-controlled review and
computer controlled review was $d = -.5$.

Morrison, Ross, and Baldwin (1992) found that giving subjects
control over the amount of practice did not lead to significantly better
performance. After each lesson subjects either practiced one item (minimum
practice), four items (maximum practice), or were allowed to choose to
practice from one to four items (learner control). No significant effect was
found for learner control: $d = -.24$ for learner-control versus minimum
practice and $d = -.34$ for learner-control versus maximum practice. Although
in this study it can be argued that those subjects in the maximum support
group received more training and performed better for that reason, it is not
clear why the subjects in the minimum support group performed better than
the subjects in the learner-control group who received more practice. In this
study, more practice did not automatically produced better performance.

Pollock and Sullivan (1990) also found evidence that the opportunity
for personal control does not necessarily enhance performance. They
investigated the effect of learner-control and practice mode on the
acquisition of scientific facts about tarantulas on a group of seventh grade
students. Students assigned to the learner-control group were able to choose whether to complete the practice questions whereas subjects in the program-control group were automatically routed to the questions. Two types of practice: recognition practice (multiple choice) and recall practice (fill in the blanks), and two types of tests (recall and recognition) were manipulated factorially. The program-control groups performed significantly better than the learner-control groups on the recognition test. The recall practice groups performed significantly better than the recognition practice groups on the recall test.

In all of these studies, learner-control interactivity was defined as control over the amount of training. In Ho et al. (1986) and Levenson et al. (1985), learner-control interactivity was defined as control over the opportunity to review or not. In Morrison et al. (1992), Murphy and Davidson (1991), and Pollock and Sullivan (1990) learner-control interactivity was defined as the opportunity to control the amount of practice. By reviewing the comparison groups, it can be seen that in seven out of nine comparison groups the group that had better performance was the group that had more training. Overall, learner-control, as it was defined, lead to better performance in four out of nine comparisons, but more training for the learner-control group was confounded with the manipulation.

Studies in which training times differed by more than 25%

Guthrie and McPherson (1992) failed to find a significant difference between using or not using an interactive program as a supplement to regular instruction. All subjects were provided with interactive computer assisted training about sport biomechanics in addition to normal lectures for half of
the weeks that they were in class. In the other half of the classes, they only had the lectures. The interactive program consisted of a hypertext module that used text, graphics, simulations, and sound. On average, students spent 9.8 extra hours in training when allowed to use the interactive program. Each student controlled the amount of the time they spent in training and the depth of instruction. The standard difference between groups was \( d = .37 \), in support of supplemental interactive instruction.

Arnold and Grabowski (1992) exposed first and second graders to an interactive video lesson of a visit to a museum and explored the effect of learner-control, learner-control with advisement, and program-control over their acquisition of new information. Students in the learner-control group were able to choose the sequence, establish their pace, review, freeze images, skip, and exit out of the lessons. Subjects in the learner-control with advisement received the same opportunities combined with suggestions that provided guidance and encouraged curiosity. Subjects in the program-control group received a predetermined sequence of the material that provided them with automatic practice items, feedback, and remediation and spent in average 25% less time in training. The learner-control with advisement group performed significantly better than learner-control group. These researchers suggested that the provision of the guidance plus the effect of the interactivity allowed this group to perform significantly better. No effect of learner-control \textit{per se} was obtained.
Studies in which training times were similar

Bosco and Wagner (1988) trained automobile workers to work with hazardous materials via interactive laser disk system (ILDS) or with classroom instruction plus video. The workers trained via ILDS worked independently with a computer and could choose topics, repeat or skip material, obtain definitions, and answer questions by using a touch screen. Both the ILDS and the classroom materials were developed at the same time and contained the same information. All subjects went through one mode of training, took the tests immediately after training, then went through the other mode of testing, and completed an attitude questionnaire about both programs. Performance was significantly better in the ILDS condition and approximately 80% of subjects indicated that they preferred the ILDS training.

Hicken, Sullivan, and Klein (1992) compared two levels of learner-control and two levels of incentive conditions on the acquisition of statistical concepts. Learner control was manipulated by comparing “LeanPlus” where the students had to actively opt for additional instruction with “FullMinus” in which they could skip items related to the current learning objective. Incentives were performance-contingent and task-contingent. The students in the “LeanPlus” group exercised greater learner-control by deviating from the program more often (solicited 32% of elective items) than the students in the “FullMinus” group (bypassed 20% of the elective items). The mean difference in training time between groups was approximately 8 seconds, but “FullMinus” group received more training items. The difference between the groups approached statistical significance, with the “FullMinus” scoring
higher than the “LeanPlus” group. It should be noted that, unlike other studies reviewed here, both groups had the opportunity for learner-control; the difference is the amount of control exercised.

Conclusion

In the two studies that controlled training time only in Bosco and Wagner (1988) is the use of interactivity supported. The utility of learner-control has not been clearly demonstrated by existing studies. The biggest problem is that training time is often confounded with learner-control: subjects given more control were also given more time to learn the task. Only one study (Bosco and Wagner, 1988) equated the training times for the groups and obtained an advantage for learner-control. Even in this study, the exact times were not reported; instead it was stated that “training times were quite similar.”

Design of the present study

This study controlled training time by “yoking” each subject in the no-learner-control condition to a subject in the learner-control condition. This meant that each subject and his or her yoked control saw the same material in the same order for the same length of time. This procedure, in addition to controlling for training time, allows the separation of the effects of learner-control per se from the effects of more efficient learning strategies. If one source of individual differences in the learner-control group is that some subjects make better choices about what to look at and for how long, then there should be a correlation between a subject’s performance and the performance of the subject yoked to him or her.
A second variable, the amount of conceptual information, was also manipulated in this study. Based on the results of a pilot study, I suspected that subjects given less conceptual information might perform better.

Schmidt and Bjork (1992) reviewed a large body of data indicating that training procedures that optimize performance immediately after training are often not the same ones that optimize performance after a delay. Therefore, subjects were tested immediately after training and after a one-week delay.
EXPERIMENT

Method

Subjects

Eighty Rice University students, 48 undergraduate students enrolled in psychology classes and 32 graduate students, participated in this study. The undergraduate students were between the ages of 18 and 28 and had, on average, completed 2 years of college. The graduate students were between the ages of 22 and 42 and had, on average, completed 2 years of graduate study.

Subjects were recruited from the subject pool and through advertisement on Rice University bulletin boards. Only students who were not diabetic and did not have a diabetic in their immediate family were allowed to participate in the study. For their participation, the undergraduate students were given course credit and the graduate students were paid $5.00.

Equipment

Three Hypercard stacks (programs) were used in this study and were presented on a Macintosh LC II (see Appendixes B and C). Testing was conducted using printed materials (see Appendix D).

Training task

The task was a simulation of a person with non-insulin dependent diabetes mellitus (NIDDM) controlling his or her blood sugar. NIDDM is a disease in which the body cannot use blood glucose efficiently and high levels of blood glucose persist in the circulatory system. The disease affects about 3.5% of the population of the United States and typically occurs after
age 40. Damage to the arterial walls by high glucose level give rise to a host of complications such as: blindness, chronic renal failure, and peripheral vascular disease (Gray, 1995).

Blood glucose levels in NIDDM sufferers are affected by a host of endogenous factors such as defective insulin secretion and action, weight, illnesses (i.e. fever and infection), and by extraneous factors such as diet, exercise, hypoglycemic medication, insulin use, and the use of other medications (Armbruster, 1993; Chipkin, Gottlieb, Bogorad, & Parker, 1996). For every patient a management plan that includes diet, exercise, and medication (if needed) is created and adjusted regularly to deal with the combined effects of all the factors that affect blood sugar level.

Management of NIDDM is based on the control of blood glucose levels through the use of diet, exercise, and oral hypoglycemics or exogenous insulin (Chipkin et al., 1996; Gray, 1995). Patients are strongly encouraged to follow their management plans in order to avoid future complications.

It is widely accepted that optimum management requires an awareness of the factors that influence blood glucose level (American Diabetes Association, 1995; Chipkin et al., 1996; Funnell & Haas, 1995; Gray, 1995). One way of increasing such awareness is continuous education and training of NIDDM patients. National standards for diabetes patient education programs were first published in 1983, and revised in 1995 to serve as a guideline on the design of educational programs to serve this population (Funnell & Haas, 1995).
Part of the management plan is routine monitoring of blood glucose levels done by the patient by means of fingerstick blood samples. The blood glucose level is the outcome of the interplay of a series of variables that can be assessed by the patient. The interplay of these variables, mainly diet, exercise, and medication, varies among individuals but is fairly constant within the same individual and management plans can be constructed based on the blood glucose records in conjunction with behavioral records (Chipkin et al., 1996).

Diagnostic skill mimics what the fingerstick blood glucose levels portray. One is able to diagnose if the blood sugar level of an hypothetical patient is high, low, or normal if the concepts of diet regulation, energy expenditure through exercise, and medication effects are understood. Knowledge retention and diagnostic skill acquisition are a measure that the information has been learned, the student is able to manipulate several concepts at the same time, and that he or she understand how variables interact and affect the outcome, namely the blood sugar level.

Training overview. All subjects were told that they would go through a training program and that they would take a test immediately after their training and again one week after. All training materials are presented in Appendix B and Appendix C.

During the first part of their training, all subjects read conceptual information about diabetes. The information was presented using a Hypercard stack. All the subjects in this portion of the training could manipulate the program to review part of the information presented to them and decide the sequence of presentation of some information. There was no
time limit for this part of the training. Two variations of the Hypercard stack were used: (1) More Conceptual Information; (2) Less Conceptual Information. The Less Conceptual Information stack was made by deleting some information from the More Conceptual Information stack, see Figure 1.

<table>
<thead>
<tr>
<th>Diabetes is a disease in which the body doesn't produce enough insulin or the insulin doesn't work as it should. Insulin helps the body to use the blood sugar that is in the blood. The food you eat is turned into blood sugar, and blood sugar provides you with the energy you need. Too little blood sugar leaves you without energy.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSULIN + BLOOD SUGAR = ENERGY TO LIVE</strong></td>
</tr>
<tr>
<td>... all three [referring to diet, exercise, and medication] are necessary to help your body control the amount of sugar that is in the blood.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A healthy body controls the amount of sugar in the blood automatically by increasing or decreasing the amount of insulin that goes into the blood. A person with diabetes has to prevent the blood sugar level from getting too high or too low by controlling what he or she does because the insulin he or she has is not enough or doesn't work as it should. Remember that: <strong>INSULIN + BLOOD SUGAR = ENERGY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>When you do not have enough insulin or the insulin you have is not working, you will have too much blood sugar left unused in your blood. Too much sugar in your blood leads to many health complications.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>... These problems [referring to heart problems and slow healing cuts and increased chance of infection] with your circulation occur because arteries harden faster for people with uncontrolled diabetes than for other people.</th>
</tr>
</thead>
<tbody>
<tr>
<td>... These problems [referring to blindness and kidney disease] occur because high blood sugar damages the small blood vessels in the body.</td>
</tr>
<tr>
<td>... This problem [referring to loss of feeling in hands and feet] occurs because high blood sugar damages the nerves.</td>
</tr>
</tbody>
</table>

**Figure 1.** Deleted information from the More Conceptual Information stack.

During the second part of training, subjects saw a Hypercard stack that presented how the variables that affect blood glucose level interact with each
other and result in the "actual blood glucose level" of a simulated patient. The presentation was based on a normal day in the life of a "diabetic patient", and focused on some of the decisions a patient makes that affect his or her blood sugar level. The day was organized from 8:00 AM to 8:00 PM. At each "hour" a different situation was presented and a series of three choices of what to do was given. Twelve such scenarios were presented. Subjects made choices such as what to eat, whether to take the medication, etc. Two variations of the Hypercard stack were used: (1) Learner-control interactive training; (2) Non-interactive training (see Appendix C).

Learner-control interactive training consisted of making decisions on what the "diabetic patient" was to do in each situation and then watching how the blood glucose level of the "patient" was affected, and what symptoms he or she had. The subjects in the interactive condition were left to explore and make any decisions they wished while their choices and times were recorded within the Hypercard stack. Each decision task started with the presentation of a scenario, three choices of what to do, a graphic display of the current of blood glucose level that reflected previous decisions. A series of events happened after their decision (while the time of day was presented as changing). First, the changes in the blood sugar level of the patient were simulated by darkening or lightening the shading in the "diabetic patient" silhouette, and by one of seven descriptives of the blood sugar level that varied from too high to too low. Second an explanation for the change in blood sugar level was presented. Third, symptoms that appear at the current blood sugar level were shown. Finally, the next time of day and a new situation was presented. After a total of 12 scenarios were
presented, the training section ended with the "patient" showing the cumulative effect of all the decisions made.

Non-interactive training consisted in watching a movie-like presentation of the choices made by a subject in the interactive group. Each subject in the non-interactive group was yoked to a subject in the interactive group that had been through their same first part of the training (more or less conceptual). The presentation resembled a slide show in which the "director" had been the learner-control interactive subject yoked to them.

**Training times.** Small differences in training times occurred due to system response time. The difference in training time between the groups that received learner-control interactive training and the groups that received non-interactive training was less than 10 seconds. There was not a significant difference in training times between all four groups; the Analysis of Variance summary table is shown in Appendix E.

**Testing overview.** All testing materials are presented in Appendix D. A written pretest was used to assess the subject's initial level of conceptual knowledge. This test asked about the things a diabetic needs to do to control his or her diabetes, health complications arising from diabetes, the factors that affect the blood sugar level in a diabetic, the factors a diabetic has to consider when diagnosing his or her blood sugar level, and the symptoms of high and low blood sugar level.

A two-part written test was used to assess performance immediately after training and again after one week. The first part of the test was the same test used for the pretest and was used to assess post-training knowledge level. The second part of the test was used to assess diagnostic skill. This test
presented scenarios similar to those given during the training session. Each situation presented a diabetic trying to decide his or her blood sugar level. In all situations the following factors were included: symptoms, diet, exercise level, medication level, illnesses present, and other factors (like weather, stress, etc.). After each scenario the subject was asked to diagnose whether the blood sugar level of the hypothetical diabetic was high, low, or normal, to explain his or her decision, and to choose a remedial action for the hypothetical diabetic (i.e. eating, taking medication and/or exercising, or doing nothing).

**Procedure**

A pretest was given to all prospective subjects to assess their diabetes knowledge level. If any had scored 50% or more they were to have been dropped from the experiment, but none of the students scored above 50%. The mean score out of 32 was 7.5, and the mode was 8.

**Training session.** Subjects were randomly assigned to one of four training conditions: (1) More Conceptual Information/Learner-Control Interactive Training; (2) More Conceptual Information/Non-interactive Training; (3) Less Conceptual Information/Learner-Control Interactive Training; (2) Less Conceptual Information/Non-interactive Training. Twenty students, 12 undergraduates and 8 graduate participated in each condition.

In the first part of their training, all subjects went through the information stack. They were required to read aloud all the information while they were tape recorded, and were told that credit was given only for tapes that showed that all the material had been read. Subjects navigated the
information at their own pace and could chose to skip or review the information presented (see Appendix B).

Subjects in the learner-control interactive condition were required to make a decision each time a new scenario was presented. They saw the consequences that their decisions had on the blood sugar level and symptoms of the "patient". They were only told to make a decision for each scenario presented, not to make the "right decision". No time limit was set for subjects in this condition.

Subjects in the non-interactive conditions were yoked to subjects in the interactive condition that had received the same amount of conceptual information that they had. They saw all the decisions, and consequences of the decisions, that their yoked partners had taken.

Testing session. The two-part paper and pencil test was given to assess performance. All subjects were tested twice, immediately after training, and again after one week. The tests were self-paced and the subjects worked on one part at the time, first on the knowledge part and then on the diagnostic skills part (these tests are shown on Appendix D). The test of knowledge was the same test used as the pretest and its total value was 32 points. The diagnostic skill test consisted of the presentation of five stories about diabetic patients, for which the subjects had to assess, based on the presented facts, whether the patient's blood sugar was low, normal, or high. Subjects had to tell why they chose a particular answer, and were required to indicate what the patient should do next. Each question counted for 3 points, the total value of the test was 15 points.
Additionally all of the subjects were asked to complete a survey that assessed how satisfied they were with the training materials. Half of the subjects completed the survey after the first testing session administered immediately after training, and the other half after the second testing session administered approximately a week after.

After completing the testing session subjects were asked not to study any material regarding diabetes, and were reminded that this study was testing the effectiveness of the training program and that their individual scores did not reflect how competent they were, but how good the program really was.

Subjects were asked to return for the second session of testing at approximately one week after the first session was completed. At that time they received the two-part test again, self-paced, one part at a time. The first part of the test (knowledge) was the same test used for the pretest and in the first testing session. The second part of the test (diagnostic skill) was similar in format to the test used in the first testing session, but used different stories.

All subjects were debriefed after the second testing session.
Results

Diagnostic Skill

The reliability of the diagnostic-skill test as measured by Cronbach's $a$ was .53. According to Nunnally (1978), this reliability is within the adequate range for the purpose of research studies.

There was no evidence of a correlation between the scores of yoked pairs. The correlation between yoked pairs for the immediate testing session was $r = -.0085$, $p = .958$ and the correlation for the delayed testing session was $r = .0384$, $p = .814$.

The means of the diagnostic skill test as a function of amount of information, level of interactivity, and time of testing are presented in Table 1.
### Table 1

**Mean Scores and Standard Deviations for the Diagnostic Skill Test at the Immediate and Delayed Testing Sessions as a Function of Group**

<table>
<thead>
<tr>
<th></th>
<th>More-conceptual information</th>
<th>Less-conceptual information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
</tr>
<tr>
<td>Interactive training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>immediate test</td>
<td>11.5</td>
<td>1.8</td>
</tr>
<tr>
<td>delayed test</td>
<td>10.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Non-interactive training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>immediate test</td>
<td>9.9</td>
<td>2.5</td>
</tr>
<tr>
<td>delayed test</td>
<td>9.8</td>
<td>2.8</td>
</tr>
</tbody>
</table>

**Note:** maximum score was 15.
As can be seen on Figure 2, the interactive training led to better performance on the diagnostic skill test at both the immediate and the delayed testing sessions. This difference was not apparent for the delayed test in the less-conceptual-information group and therefore some caution must be exercised interpreting the effect for this group.

![Graph showing performance comparison between interactive and non-interactive groups in immediate and delayed testing sessions.](image)

**Figure 2.** Performance of all groups on the diagnostic test at the immediate and delayed testing sessions
Box plots portraying diagnostic skill performance as a function of interactivity of training are shown in Figure 3.

**Figure 3.** Mean performance of interactive versus non-interactive groups on the diagnostic task

The main effect of interactivity evident in Figures 2 and 3 was significant, $F(1,76) = 6.84, p = .011$. No other effects were significant. The Analysis of Variance summary table is shown in Appendix E.
Knowledge Level

The reliability of the knowledge test using was Cronbach's a was .86. The performance of subjects within yoked pairs was independent. The correlation between yoked pairs for the immediate testing was $r = -.212, p = .188$ and for the delayed testing was $r = -.083, p = .607$.

The mean scores on the knowledge test as a function of amount of information, level of interactivity, and time of testing are presented in Table 2.

Table 2
Mean Scores and Standard Deviations for the Knowledge Test at the Immediate and Delayed Testing Sessions as a Function of Group

<table>
<thead>
<tr>
<th></th>
<th>More-conceptual information</th>
<th>Less-conceptual information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
</tr>
<tr>
<td>Interactive training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>immediate test</td>
<td>22.9</td>
<td>5.7</td>
</tr>
<tr>
<td>delayed test</td>
<td>20.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Non-interactive training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>immediate test</td>
<td>25.0</td>
<td>4.5</td>
</tr>
<tr>
<td>delayed test</td>
<td>21.6</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Note: Maximum score was 32.
Figure 4. Performance of all groups on the knowledge test at the immediate and delayed testing sessions

An inspection of Table 2 and Figure 4 shows that performance immediately after training was superior to performance after one week. This effect was significant, $F(1,76) = 52.26, p < .0005$. No other effects were significant. The Analysis of Variance summary table is shown in Appendix E.
Satisfaction with Training Program

Regardless of group assignment, students who completed the survey after one week were less satisfied with their training than were students who completed the survey immediately after training. Box plots showing this effect are shown in Figure 5 (higher scores indicate greater dissatisfaction). This difference was significant, $F (1,72) = 8.71, p = .004$. No significant correlation was found between satisfaction with the training program and overall performance in either the knowledge or diagnostic skills measures.

![Box plots showing dissatisfaction]

**Figure 5.** Mean survey scores as a function of testing session
Discussion

This study explored the effect that characteristics of the information and the method of training have on the acquisition and retention of knowledge and diagnostic skills. Previous criticisms by other researchers (Milheim & Martin, 1991; Reeves, 1993; Schmidt & Bjork, 1992) were addressed by this study by (1) having an objective definition and manipulation of learner-control, (2) controlling training times and amount of training, (3) measuring performance immediately after training and again after one week.

Subjects assigned to the interactive condition had control over part of the content of their training. By making the decisions for the simulated patient, they saw the consequences of their actions. On the other hand, subjects in the non-interactive condition had absolutely no control over the content of their training. Subjects in the interactive condition could also control the degree of pacing; subjects in the non-interactive condition did not have that opportunity.

Training time was controlled by yoking each subject in the non-interactive group to a subject in the interactive group that had the same amount of conceptual information. As discussed in the review of learner-control interactive research, if amount and training time are not controlled then they become confounded variables. From that previous review it was not clear whether the effects seen were due to the training time differences or to the interactive presentation of the information. This confounding
variable was eliminated from the design by the yoking manipulation, and the effects seen can be attributed to interactivity and not to more training.

Subjects receiving interactive training significantly outperformed subjects receiving non-interactive training in the diagnostic skills test at the time of acquisition and again when retention was measured after one week. Measuring performance immediately after training and again in the future becomes important as a design feature as research on training becomes the basis for the design of future training programs. The finding that learner-control interactivity promoted better performance that was sustained over time supports the assertion that interactivity should be used in the design of training programs whenever feasible.

The fact that the subjects who received interactive training chose their own course of action might have allowed them to explore the effects of those factors that were not clear to them after reading and reviewing the information section of the training materials. Thus each individual subject could tailor the training program to meet his or her own needs. Another possible explanation for the effect is that learner-control and active participation on the decision process might have led to overall increased processing and attention.

The failure to find a correlation between the scores of yoked pairs indicates that some patterns of interacting with the interactive system were not generally better than others. This supports the notion that it is the interaction with the system per se that is important.

It was also found that the level of interactivity had no effect on the knowledge level test immediately or again after one week of training.
Therefore testing only knowledge retention after giving interactive practice does not necessarily reveal the effects of interactivity.

The deletion of some of the information did not enhance or diminish the acquisition of the information, or the acquisition, performance and retention of the diagnostic skill. All subjects received both conceptual and procedural information during the course of training and were equally capable of diagnosing the blood sugar level and choosing among remedial actions. It is important to note that the addition of more information was not beneficial on its own, and that this suggests that restraint should be exercised over adding "everything there is to know" about a certain domain in a training program.

In conclusion, this study supports the use of interactive training. Only one previous study that did not confound interactivity and training time has shown an advantage of learner-control (Bosco & Wagner, 1988). The present data support the conclusions of Bosco and Wagner and extend them by showing that the advantage of learner-control does not dissipate after a delay of a week.

Caution should be exercised generalizing these data to other tasks and to other subject populations. The subjects used in this study were college students and therefore one must await further studies to see how well these conclusions hold with less well educated populations.
REFERENCES


Armbruster, M., (1993). *Diabetes education program: Revised four-module program*. Unpublished manuscript, Harris County Hospital District Community Health Program, Houston, TX.


## APPENDIX A

Summary table of studies that manipulated learner-control interactivity

<table>
<thead>
<tr>
<th>Study and comparison groups</th>
<th>Standardized difference</th>
<th>Training times</th>
<th>Is more training related to better performance?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnone and Grabowski (1992)</td>
<td>d = -.09</td>
<td>LC= 17.83 min. PC= 13.54 min. difference = 4.29 min. LA= 18.02 min.; PC= 13.54 min., difference = 4.48 min.</td>
<td>No</td>
</tr>
<tr>
<td>*learner-control (LC) vs. program-control</td>
<td>d = .29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*learner-control with advisement (LA) vs. program-control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bosco and Wagner (1988)</td>
<td>d = .95</td>
<td>Stated that: &quot;training times were quite similar&quot;.</td>
<td>No</td>
</tr>
<tr>
<td>*interactive laser disk vs. classroom instruction + video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guthrie and McPherson (1992)</td>
<td>d = .37</td>
<td>Supplemental instruction consisted of an average of 9.8 extra hours.</td>
<td>Yes</td>
</tr>
<tr>
<td>*supplemental interactive instruction vs. no supplemental instruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Effect Size</td>
<td>Outcome Description</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Hicken, Sullivan, and Klein (1992)</td>
<td>(d = -0.32)</td>
<td>“LeanPlus” was 102.61 min. “FullMinus” was 102.47 min. difference was 0.14 min.</td>
<td>Yes. “Full Minus” received more training</td>
</tr>
<tr>
<td>*“LeanPlus” (more learner-control) vs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* “FullMinus” (less learner-control)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ho, Savenye, and Haas (1986)</td>
<td>(d = -0.5)</td>
<td>Times not reported.</td>
<td>Yes. Computer-controlled received more training.</td>
</tr>
<tr>
<td>*learner-controlled led review vs.</td>
<td></td>
<td></td>
<td>Yes. Learner-controlled received more training.</td>
</tr>
<tr>
<td>computer-controlled review</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*learner-controlled led review vs. no-review</td>
<td>(d = 1.32)</td>
<td>Times not reported.</td>
<td></td>
</tr>
<tr>
<td>Levenson, Morrow, and Signer (1985)</td>
<td>(d = 1.38)</td>
<td>Times not reported.</td>
<td>Yes. Interactive group received more training.</td>
</tr>
<tr>
<td>*interactive video vs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-interactive group video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*interactive video vs.</td>
<td>(d = 0.93)</td>
<td>Times not reported.</td>
<td>Yes. Interactive group received more training.</td>
</tr>
<tr>
<td>non-interactive individual video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Effect Size</td>
<td>Times Reported</td>
<td>Additional Notes</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Morrison, Ross, and Baldwin (1992)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*learner-control of practice vs. minimum</td>
<td>d = -.24</td>
<td>Times not</td>
<td>No. Learner-control received more practice.</td>
</tr>
<tr>
<td>practice</td>
<td></td>
<td>reported.</td>
<td></td>
</tr>
<tr>
<td>*learner-control of practice vs. maximum</td>
<td>d = -.34</td>
<td>Times not</td>
<td>Yes. Maximum received more practice.</td>
</tr>
<tr>
<td>practice</td>
<td></td>
<td>reported.</td>
<td></td>
</tr>
<tr>
<td>Murphy and Davidson (1991)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*learner-control vs. adaptive control on</td>
<td>d = .10</td>
<td>Times not</td>
<td>Yes. Learner-control received more training.</td>
</tr>
<tr>
<td>long term performance</td>
<td></td>
<td>reported.</td>
<td>No. Learner-control received more training.</td>
</tr>
<tr>
<td>*learner-control + advisement vs.</td>
<td>d = -.02</td>
<td>Times not</td>
<td></td>
</tr>
<tr>
<td>adaptive-control on long term performance</td>
<td></td>
<td>reported.</td>
<td></td>
</tr>
<tr>
<td>Pollock and Sullivan (1990)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*learner-control vs. program-control on the</td>
<td>d = -.24</td>
<td>Times not</td>
<td>Yes. Program-control receive more training.</td>
</tr>
<tr>
<td>recognition test</td>
<td></td>
<td>reported.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

Stack used to manipulate the amount of conceptual information

This sequence shows all the cards this stack contained. The following sequence is shown as an example. Subjects were able to decide how much time to spend, whether to review or not, and the sequence of presentation of the cards.

INTRODUCTION
INSTRUCTIONS:

1. READ ALOUD ALL THE INFORMATION PRESENTED IN EACH CARD.

2. TO GO FORWARD TO NEW INFORMATION, OR BACK TO PREVIOUS INFORMATION PRESS, THE BUTTONS AT THE BOTTOM OF THE SCREEN.
Mr. Green has type II diabetes. He was working in his garden one afternoon and suddenly felt very ill. He wondered if his blood sugar is out of control. He stopped working and thought about how he felt and what he had done up to that moment. He knows that just considering one thing, for example the symptoms, is not enough to tell if his blood sugar is too high, too low, or normal.

He thought about:

1. Symptoms: He feels tired, weak, dizzy and has blurry vision.

2. Diet: He had a very light breakfast, skipped lunch, and it is now 2:00 PM.

3. Exercise: He has been working in the garden for two hours.

4. Illnesses: He is not ill.

5. Other factors: He cannot remember any other factors that can make him feel like this.

Do you think his blood sugar level is too high, too low, or normal?
This program has been designed as a tool for teaching diabetics how to handle situations like the one you just read. Next you will be learning about the things diabetics need to know and need to do.

With this program we will teach you:

1. about diabetes.

2. what causes high and low blood sugar.

3. how to tell whether your blood sugar is too high, too low, or normal.
Basic information about diabetes as a disease.

ABOUT DIABETES

If you have diabetes, being able to predict whether your sugar is too high, too low, or normal is very important. Only by testing your blood can you know for sure. Having an idea of what your sugar level is likely to be can help you:

1. when you cannot test it.
2. to monitor yourself during the day.
3. know when you have to test it.

Diabetes is a serious disease. It can lead to other health problems you may be able to prevent if you take care of yourself.
Diabetes is a disease in which the body doesn't produce enough insulin or the insulin doesn't work as it should.

Insulin helps the body to use the blood sugar that is in the blood.

The food you eat is turned into blood sugar, and blood sugar provides you with the energy you need. Too little blood sugar leaves you without energy.

INSULIN + BLOOD SUGAR = ENERGY TO LIVE

Diabetes can be controlled with diet, exercise, and medication. All three are necessary to help your body control the amount of sugar that is in the blood.

A healthy body controls the amount of sugar in the blood automatically by increasing or decreasing the amount of insulin that goes into the blood.

A person with diabetes has to prevent the blood sugar level from getting too high or too low by controlling what he or she does because the insulin he or she has is not enough, or doesn’t work as it should.

Remember that: INSULIN + BLOOD SUGAR = ENERGY

When you do not have enough insulin or the insulin you have is not working, you will have too much blood sugar left unused in you blood. Too much sugar in your blood leads to many health complications.
HEALTH PROBLEMS ASSOCIATED WITH HAVING DIABETES

1. heart problems

2. slow healing cuts and increased chance of infections

These problems with your circulation occur because arteries harden faster for people with uncontrolled diabetes than for other people.

3. blindness

4. kidney disease

These problems occur because high blood sugar damages the small blood vessels in the body.

5. loss of feeling in hands and feet

This problem occurs because high blood sugar damages the nerves.
Cause and effect information.

WHAT CAUSES HIGH AND LOW BLOOD SUGAR

FACTORS THAT AFFECT THE BLOOD SUGAR LEVEL

Please press any button
- diet
- exercise
- medication
- illnesses
ABOUT DIET

Basic facts:

1. Eating increases blood-sugar and blood-fat levels.
2. Missing a meal lowers the amount of sugar that is in the blood.

DIET COMPOSITION

1. Each serving has about the same amount of calories and raises the blood sugar level by about the same amount.
2. Foods that are high in simple carbohydrates will raise the blood sugar the fastest.
3. Foods are divided into six groups: starch/bread; meat; vegetables; fruits; milk; and fats.
This card shows animation.

Press one button at a time and observe what happens to your blood sugar level when you eat:
- 1/2 bagel
  - OR
- 2 big apples
  - OR
- 3 oz. chicken (small drumstick)
  - OR
- 1 tsp. of butter
  - OR
- 1 cup of skim milk
  - OR
- 1 chocolate chip cookie
  - OR
- 4 1/2 cups of cooked carrots

resting level

blood sugar

go back

go next
Press one button at a time and observe what happens to your blood sugar level when you eat:

**press** 1/2 bagel
OR 2 big apples
OR 3 oz. chicken (small drumstick)
OR 1 tsp. of butter
OR 1 cup of skim milk
OR 1 chocolate chip cookie
OR 4 1/2 cups of cooked carrots

Serving sizes of the foods you ate:

1/2 bagel: 1 serving
2 apples: 2 servings
3 oz. chicken: 3 servings
1 tsp. of butter: 1 serving
1 cup of skim milk: 1 serving
1 chocolate chip cookie: 2 servings
4 1/2 cups of cooked carrots: 3 servings
DIET RECOMMENDATIONS

1. Eat less fat.

2. Eat more complex carbohydrates, especially those high in fiber.

3. Eat less sugar.

4. Use less salt.

5. Use alcohol in moderation.

6. Eat your meals at about the same time each day.

7. Divide your food into 20% for breakfast, 35% for lunch, 30% for dinner, and 15% for late-evening.

FACTORS THAT AFFECT THE BLOOD SUGAR LEVEL

Please press any button:

- diet
- exercise
- medication
- illnesses
Facts:

1. Exercising decreases the amount of blood sugar that is in the blood, because blood sugar is turned into energy.

This card shows animation

Press one button at a time and observe what happens to your blood sugar level when you exercise:

- [press] walking fast for 45 minutes
  OR
- [press] mild aerobic dancing for 1/2 hour
  OR
- [press] general housework for 2 hours
  OR
- [press] gardening and weeding for 15 minutes
  OR
- [press] bicycling at 5.5 mph for 45 minutes
Press one button at a time and observe what happens to your blood sugar level when you exercise:

- **press** walking fast for 45 minutes
  - OR
- **press** mild aerobic dancing for 1/2 hour
  - OR
- **press** general housework for 2 hours
  - OR
- **press** gardening and weeding for 15 minutes
  - OR
- **press** bicycling at 5.5 mph for 45 minutes

**blood sugar**

**resting level**
Calories spent in exercise:

walking fast for 45 minutes: 240 calories
mild aerobic dancing for 1/2 hour: 150 calories
general housework for 2 hours: 220 calories
gardening and weeding for 15 minutes: 80 calories
bicycling at 5.5 mph for 45 minutes: 190 calories

FACTORS THAT AFFECT THE BLOOD SUGAR LEVEL

Please press any button

- diet
- exercise
- medication
- illnesses
ABOUT MEDICINE

Facts:

1. Medicine decreases the amount of blood sugar that is in the blood.

2. If taken as prescribed, it helps to maintain the blood sugar at the appropriate level because it helps the insulin to work better.

FACTORS THAT AFFECT THE BLOOD SUGAR LEVEL

Please press any button

- diet
- exercise
- medication
- illnesses
About Illnesses

Facts:

1. Other minor illnesses like colds and flu can make your blood sugar go up because, in the days that you are sick, your body needs more help to control the blood sugar level than at other times.

Integrating the information.

How to tell whether your blood sugar is too high, too low, or normal
You can estimate if your blood sugar level is too high, too low, or normal by taking into account the things that you have done up to that moment and any symptoms you may have.

- diet
- exercise
- medication
- illnesses
- other factors

Do you have any symptoms?

To learn about the symptoms of high and low blood sugar level please go to next card

- high blood sugar level
- low blood sugar level
SYMPTOMS OF HIGH BLOOD SUGAR

1. increased thirst
2. increased urination
3. drowsiness or sleepiness
4. dry, itchy skin

If your blood sugar is getting high you will feel these symptoms gradually increasing as time goes by. Your blood sugar can be high without you feeling any symptoms.

SYMPTOMS OF LOW BLOOD SUGAR

1. tiredness and weakness
2. dizziness
3. feeling of confusion
4. feeling cold, clammy and sweaty
5. blurry vision
6. nervousness

As opposed to the symptoms of high blood sugar, you will feel the symptoms of low blood sugar more suddenly. Your blood sugar level cannot be low if you do not have at least one of these symptoms.
<table>
<thead>
<tr>
<th>Symptoms of High Blood Sugar:</th>
<th>Symptoms of Low Blood Sugar:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Thirst</td>
<td>Tiredness, Weakness</td>
</tr>
<tr>
<td>Frequent Urination</td>
<td>Dizziness</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>Confusion</td>
</tr>
<tr>
<td>Dry, Itchy Skin</td>
<td>Blurry Vision</td>
</tr>
<tr>
<td></td>
<td>Nervousness</td>
</tr>
<tr>
<td></td>
<td>Cold Clammy Sweat</td>
</tr>
</tbody>
</table>

You have finished the information section of this program.

Please let me know.
APPENDIX C

Stack used to manipulate the level of learner-control interactivity

This sequence shows all the cards this stack contains. The following sequence is shown as an example. Subjects in the interactive condition were able to decide how to answer each of the questions. For the first situation "Choose what to have for breakfast", the full sequence is presented. For all following situations only the first and the last cards are presented.

Introduction
Practice Session

press here for instructions

Instructions:

1. You will be choosing different things that people do during the course of a day, and as you choose you will see some changes in the blood sugar level and in the symptoms.

2. The blood sugar level at any moment in time is affected by what you have chosen before.

press here

←
Cause and effect presentations.

Choose what to have for breakfast

8:00 am

blood sugar level

too high
higher
high
normal
low
lower
too low

symptoms

2 eggs with bacon, 3 pieces of toast and butter, fruit, milk and juice

10 servings select
no breakfast

0 servings select
1 egg
2 pieces of toast
small glass of juice

4 servings select

Choose what to have for breakfast

8:15 am

blood sugar level

too high
higher
high
normal
low
lower
too low

symptoms

2 eggs with bacon, 3 pieces of toast and butter, fruit, milk and juice

10 servings select
no breakfast

0 servings
1 egg
2 pieces of toast
small glass of juice

4 servings
Choose what to have for breakfast

2 eggs with bacon, 3 pieces of toast and butter, fruit, milk, and juice

10 servings
no breakfast

0 servings

1 egg
2 pieces of toast
small glass of juice

4 servings

Too many servings, food high in fat and sugar will raise the blood sugar too much.

blood sugar level
too high
higher
high
normal
low
lower
too low

symptoms

9:00 am

Do you want to exercise?

I will exercise as indicated, moderately for 20 minutes.

select

I will exercise more than usual, vigorously for 45 minutes.

select

I will not exercise today.

select

blood sugar level
too high
higher
high
normal
low
lower
too low

symptoms

9:00 am
Do you want to exercise?

I will exercise as indicated, moderately for 20 minutes.

I will exercise more than usual, vigorously for 45 minutes.

I will not exercise today.

10:00 am

blood sugar level

symptoms

too high
higher
high
normal
low
lower
too low

Do you want to take your diabetes medicine?

Yes, I will take the medication as prescribed.

No, I do not want to take the medication at this time.

10:00 am

blood sugar level

symptoms

too high
higher
high
normal
low
lower
too low
Do you want to take your diabetes medicine?

Yes, I will take the medication as prescribed.

No, I do not want to take the medication at this time.

Are you ill?

No, I am not ill.

Yes, I have a cold, and I am running a fever.
Are you ill?

No, I am not ill.

Yes, I have a cold, and I am running a fever.

Choose what to have for lunch.

I will have a salad, a chicken leg, a roll, and a diet coke.

5 servings

I do not want to have lunch.

0 servings

I will have a burger with fries, a milkshake, and cake.

15 servings

blood sugar level

too high
higher
high
normal
low
lower
too low

symptoms

12:00 am
Choose what to have for lunch.

1:00 pm

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy

I will have a salad, a chicken leg, a roll, and a diet coke.
5 servings

I do not want to have lunch.

0 servings

I will have a burger with fries, a milkshake, and cake
15 servings

Choose what has happened today.

1:00 pm

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy

It is very hot today.

I have not had time to sit down and rest.

Everything is OK.
Choose what has happened today.

It is very hot today.

I have not had time to sit down and rest.

Everything is OK.

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy
- tired and weak

Will you take your diabetes medicine?

Yes, I will take the medication as prescribed.

No, I do not want to take the medication at this time.

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy
- tired and weak
Will you take your diabetes medicine?

Yes, I will take the medication as prescribed.

3:00 pm

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy

No, I do not want to take the medication at this time.

Choose an activity.

Light gardening.

3:00 pm

blood sugar level
- too high
- higher
- high
- normal
- low
- lower
- too low

symptoms
- tired and weak
- a little bit dizzy

Reading a book.
Choose an activity.

4:00 pm

- Light gardening
- Reading a book

Symptoms:
- Too high: tired and weak
- Higher: a little bit dizzy
- High: normal
- Normal: low
- Low: lower
- Too low

Do you want to have a snack?

4:00 pm

- Yes, I will have 2 donuts and coffee
- Yes, I will have an apple
- I don't want a snack

Symptoms:
- Too high: tired and weak
- Higher: a little bit dizzy
- High: normal
- Normal: low
- Low: lower
- Too low
Do you want to have a snack?

Yes, I will have 2 donuts and coffee.

4 servings

Yes, I will have an apple.

1 serving

No, I don't want a snack.

0 servings

Choose an activity.

Watching TV.

Light housework.

5:00 pm

blood sugar level

symptoms

too high

higher

high

normal

low

lower

too low

practice stackused
Choose an activity.

Watching TV.

Light housework.

6:00 pm

Blood sugar level

Too high
Higher
High
Normal
Low
Lower
Too low

Choose what to have for dinner.

I don't want to have dinner.

0 servings

Select

Fish, a baked potato, green beans, carrots, and iced tea

7 servings

Select

2 pork chops, baked potato with sour cream, roll, carrots, chocolate cake, and a glass of milk

15 servings

Select

6:00 pm

Blood sugar level

Too high
Higher
High
Normal
Low
Lower
Too low
Choose what to have for dinner.

0 servings
fish, a baked potato, green beans, carrots, and iced tea

7 servings
2 pork chops, baked potato with sour cream, roll, carrots, chocolate cake, and a glass of milk

Choose what happened.

I received bad news from home.

I have been working very hard this week.

I got a sun tan yesterday.
Choose what happened.

I received bad news from home.

I have been working very hard this week.

I got a sunburn yesterday.

8:00 pm

blood sugar level

symptoms

too high
higher
high
normal
low
lower
too low

e little bit thirsty
dry and itchy skin

The End
APPENDIX D

Tests used to assess performance

PRE-TEST

Part I: Please answer the following questions:
1. Name the three things that a diabetic needs to do to control his/her diabetes
a. 
   b. 
   c. 
2. Name the health complications or illnesses associated with having high blood sugar levels:
   a. 
   b. 
   c. 
   d. 
   e. 
3. What raises the blood sugar of a diabetic person?
   a. 
   b. 
   c. 
   d. 
4. What are the factors a diabetic person has to consider when he/she is trying to tell whether his/her blood sugar is out of control and that person cannot do a blood test:
   a. 
   b. 
   c. 
   d. 
   e. 
   f.
5. Please put an L besides all the symptoms of low blood sugar, an H besides all the symptoms of high blood sugar, and an N besides all the symptoms not associated with high or low blood sugar.

___ drowsiness
___ confusion
___ blurry vision
___ muscle soreness
___ trouble sleeping
___ tiredness and weakness
___ no appetite
___ dry itchy skin
___ rash
___ cold clammy sweat
___ unusual thirst
___ frequent urination
___ nervousness
___ dizziness

6. How would you characterize your knowledge about diabetes:

1 2 3 4 5 6

NOVICE EXPERT
TEST IMMEDIATELY AFTER TRAINING

Part I: Same as the pre-test questions 1 through 5.

Part II: Read the story and answer the questions

1. John is sitting at home watching TV. He has not been feeling well for a while. He is wondering if something is wrong with his blood sugar.
   SYMPTOMS: He does not feel well, but he cannot explain what he feels.
   DIET: He had the proper breakfast at 9:00, the correct lunch at 12:00. He also had several pieces of peppermint candy and a big glass of fruit punch.
   EXERCISE: He has not had any exercise in days and has been watching TV all day.
   MEDICINE: He has been taking his medicine.
   ILLNESSES: He is not sure if he caught something.
   OTHER: He cannot think of other reasons why he should feel as he does.

   • John probably has **HIGH** **LOW** **NORMAL**
   blood sugar level. (circle the answer)
   • Briefly tell why:
   • He should: **EAT TAKE MEDICATION AND/OR EXERCISE**
   **DO NOTHING** to make the blood sugar level normal. (circle the answer)

2. Mary went to work in a hurry this morning. She is there now and has not been able to concentrate on her work.
   SYMPTOMS: Confused, her skin is cold and clammy.
   DIET: She skipped breakfast.
   EXERCISE: She has been sitting down all morning.
   MEDICINE: She took her medicine on time.
   ILLNESSES: She has no other illnesses.
   OTHER: She cannot think of other reasons why she should feel as she does.

   • Mary probably has **HIGH** **LOW** **NORMAL**
   blood sugar level. (circle the answer)
   • Briefly tell why:
   • She should **EAT TAKE MEDICATION AND/OR EXERCISE**
   **DO NOTHING** to make the blood sugar level normal. (circle the answer)
3. Today is the day that Joan cleans her house. Normally it would take her two hours to finish. Today she has been working for one half hour and is so tired that she needs to sit down. She is wondering if something is happening to her sugar level. She looks at her watch, and it is 3:00 PM.
SYMPTOMS: She is running a fever. She feels drowsy and tired.
DIET: She had the proper breakfast and lunch.
EXERCISE: She has not been exercising too much.
MEDICINE: She has been taking her diabetes medicine on time.
ILLNESSES: She has a terrible cold.
OTHER: She cannot think of other reasons why she should feel as she does.

• Joan probably has **HIGH**     **LOW**     **NORMAL**
  blood sugar level. (circle the answer)
• Briefly tell why:
• She should **EAT**  **TAKE MEDICATION AND/OR EXERCISE**
  **DO NOTHING**  to make the blood sugar level normal. (circle the answer)

4. Today is the day that Paul, Joan's brother, cleans his house. Normally it would take him two hours to finish. Today he has been working for one half hour, and he suddenly feels so tired, dizzy, and nervous that he needs to sit down. He is wondering if something is happening to his blood sugar level. He looks at his watch, and it is 2:00 PM.
SYMPTOMS: He suddenly feels tired, dizzy, and nervous.
DIET: He had the proper breakfast and a very small lunch.
EXERCISE: He jogged this morning after breakfast more than he usually does, for 40 minutes.
MEDICINE: He has been taking his diabetes medicine on time.
ILLNESSES: He has no other illnesses.
OTHER: He cannot think of other things that will make him feel as he does.

• Paul probably has **HIGH**     **LOW**     **NORMAL**
  blood sugar level. (circle the answer)
• Briefly tell why:
• He should **EAT**  **TAKE MEDICATION AND/OR EXERCISE**
  **DO NOTHING**  to make the blood sugar level normal. (circle the answer)
5. Jim is thirsty and drowsy after having his lunch.
SYMPTOMS: He is thirsty and drowsy.
DIET: He has been following his diet.
EXERCISE: He has been exercising normally.
MEDICINE: He took an antihistamine medicine (actifed) and his diabetes medicine.
ILLNESSES: His allergy is acting up.
OTHER: He thinks he might be thirsty because his lunch was a bit salty.

- Jim probably has HIGH LOW NORMAL blood sugar level. (circle the answer)
- Briefly tell why:
- He should EAT TAKE MEDICATION AND/OR EXERCISE DO NOTHING to make the blood sugar level normal. (circle the answer)
TEST AFTER ONE WEEK

Part I: Same test as in previous test

Part II: Read the story and answer the questions

1. John is sitting at home watching TV. He has not been feeling well for a while. He is wondering if something is wrong with his blood sugar.
   SYMPTOMS: He does not feel well; he feels a little bit dizzy.
   DIET: He had no breakfast and a small lunch at 12:00.
   EXERCISE: He has not had any exercise in days and has been watching TV all day.
   MEDICINE: He has been taking his diabetes medicine.
   ILLNESSES: He is not ill.
   OTHER: He cannot think of other reasons why he should feel as he does.

   • John probably has HIGH LOW NORMAL blood sugar level. (circle the answer)
   • Briefly tell why:
   • He should EAT TAKE MEDICATION AND/OR EXERCISE DO NOTHING to make the blood sugar level normal. (circle the answer)

2. Janet has been doing errands all afternoon. When she got out of the car at the grocery store she felt bad.
   SYMPTOMS: She feels thirsty and tired, and her skin is hot.
   DIET: She had the proper breakfast and lunch.
   EXERCISE: She has been exercising regularly.
   MEDICINE: She took her medicine on time.
   ILLNESSES: She has no other illnesses
   OTHER: It is a very hot day, and she is not used to hot weather yet.

   • Janet probably has HIGH LOW NORMAL blood sugar level. (circle the answer)
   • Briefly tell why:
   • She should EAT TAKE MEDICATION AND/OR EXERCISE DO NOTHING to make the blood sugar level normal. (circle the answer)
3. Joan likes to walk a lot after breakfast. Today she decided to go through a new route. She walked an extra hour to get back home.
SYMPTOMS: She feels tired and a little bit nervous.
DIET: She had a proper breakfast, the same she always has before walking.
EXERCISE: She exercised for an extra hour.
MEDICINE: She has been taking his diabetes medicine on time.
ILLNESSES: She is not ill.
OTHER: She cannot think of other things that will make her feel as she does.

• Joan probably has HIGH LOW NORMAL blood sugar level. (circle the answer)
• Briefly tell why:
• She should EAT TAKE MEDICATION AND/OR EXERCISE DO NOTHING to make the blood sugar level normal. (circle the answer)

4. Paul is home on his vacation.
SYMPTOMS: He has no symptoms.
DIET: He has eaten a lot of fried foods lately. Today he had a big breakfast and lunch, and two peaches and a pear as a snack.
EXERCISE: He has not exercised for a while.
MEDICINE: He has been taking his diabetes medicine.
ILLNESSES: He has no other illnesses.
OTHER: He has been watching a lot of TV lately.

• Paul probably has HIGH LOW NORMAL blood sugar level. (circle the answer)
• Briefly tell why:
• He should EAT TAKE MEDICATION AND/OR EXERCISE DO NOTHING to make the blood sugar level normal. (circle the answer)
5. Jim is thirsty and drowsy after having his lunch.
SYMPTOMS: He is thirsty and drowsy.
DIET: He has been eating normally, as he usually does.
EXERCISE: He stopped exercising two weeks ago.
MEDICINE: He took his diabetes medicine on time.
ILLNESSES: He has no other illnesses.
OTHER: He cannot think of other things that will make him feel like he does.

• Jim probably has **HIGH**  **LOW**  **NORMAL** blood sugar level. (circle the answer)
• Briefly tell why:
• He should **EAT**  **TAKE MEDICATION AND/OR EXERCISE**  **DO NOTHING**  to make the blood sugar level normal. (circle the answer)
SURVEY: SATISFACTION WITH TRAINING

1. I understood all the information that was included in this program:
   yes  
   | 1 | 2 | 3 | 4 | 5 | no  | 6 |

2. This program provided all the information that I needed to answer the questions:
   yes  
   | 1 | 2 | 3 | 4 | 5 | no  | 6 |

3. Anyone can use this program and be able to answer the questions.
   yes  
   | 1 | 2 | 3 | 4 | 5 | no  | 6 |

4. The illustrations of this program were:
   helpful  
   | 1 | 2 | 3 | 4 | not helpful | 5 | 6 |

5. I am satisfied with this program:
   yes  
   | 1 | 2 | 3 | 4 | 5 | no  | 6 |
APPENDIX E
Statistical analyses

Analysis of Variance for Training Times

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G: Group assignment: More/Interactive; More/Non-interactive; Less/Interactive; Less/Non-interactive

Analysis of Variance for Diagnostic Skills Performance

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### Analysis of Variance for Knowledge Performance

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Analysis of Variance for the Satisfaction Survey

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Correlation of Performance Score and Survey Score

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slope = -0.1266 \\
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\]